tailings in the deep ocean and their biological impacts is a significant cause for concern." The material can smother ecosystems at the disposal site, and if toxic metal ions are released into the water they may end up in the food web. The EU is currently producing new guidelines for best practice in the marine disposal of mining waste.

On top of these legally permitted assaults on the oceans, there are the irregular and illegal waste disposals which are very difficult to police on the oceans, along with the accidental pollution from shipwrecks and accidents on drilling platforms. Large numbers of ships rest on the sea floor, where the more modern ones may be slowly leaking their fuel and toxic materials. Until the case of the Shell platform Brent Spar made headlines around the world in 1995, it was also deemed acceptable to dump such vast structures instead of towing them back for recycling on land.

Finally, the swelling tide of plastic waste washed out to sea and broken down to microscopic particles that may enter the food web has become a considerable concern over recent years (Curr. Biol. (2015) *25*, R93–R96). Overall, the oceans, including the deeper waters, are already exposed to large amounts of anthropogenic pollution, and much more research will be needed to establish how this will affect the ecology of the oceans.

Conflicts of conscience

While the problems outlined above can mostly be described as conflicts between economic interests and the conservation of a natural environment, there is also the growing prospect of environmentally motivated actions that will in turn impact the marine environment, requiring carefully balanced decisions based on sound scientific knowledge.

Even the greenest technologies can have side effects. Off-shore wind turbines, for instance, require sacrificial anodes, which release large amounts of zinc into the water. Tidal energy installations may disrupt the local ecosystems, as large hydroelectric dams do on land.

The EMB report discusses in detail the prospect of producing 'blue energy' from the temperature gradient between the cold deep waters (2°C) and warm surface waters. As a temperature difference of at least 20°C is required for economic efficiency, this would only be an option in tropical waters. Compared with solar and wind power, the Ocean Thermal Energy Conversion (OTEC) technology has the advantage that it can supply a constant baseload at all times. It is particularly competitive when supplying island and coastal locations that are far from conventional power sources.

An open system allowing seawater itself to circulate between the layers would produce an unnatural mixing process that could have side effects, the report notes. By contrast, a closed system with a sealed-in liquid circulating could avoid this and achieve higher efficiency using other fluids such as ammonia. In any case, the industrial scale required to make such installations economically viable, along with the surrounding infrastructure, are likely to have an environmental impact.

The company Lockheed Martin is currently developing a 10MW OTEC plant for a zero-carbon resort to be built in southern China, which is due to become operational in 2017.

While OTEC plants may stir up the oceans locally and to a modest extent, more dramatic effects are expected from plans to avert catastrophic climate change by fiddling with the Earth system, also known as geo-engineering. Some of the interventions considered, like iron fertilisation with a view to increase carbon sequestration (Curr. Biol. (2009) *19*, R143–R144), are also bound to affect the deep waters.

In all of these issues likely to impact upon the ecology of the deep sea, it is obvious that our scientific knowledge base is not nearly sufficient to warrant that we can find ways of developing the blue economy in a sustainable way. If the industrialisation of the deep sea rushes ahead and the science comes trundling after to assess the collateral damage, humanity is bound to repeat on the sea floor the same mistakes it has made on land. For the sake of the life blood of our blue planet, we should put scientific understanding first.

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Q & A

Tatsuo Fukagawa

Tatsuo Fukagawa was born and brought up in Tokyo, Japan. He graduated from Hokkaido University in 1991 and earned his PhD in Genetics from the National Institute of Genetics (Department of Genetics, Graduate University for Advanced Studies) in 1995. As a postdoc, Tatsuo ("Tats") worked with William Brown in Ed Southern's lab in the Department of Biochemistry at the University of Oxford, where he established a technique to efficiently engineer genomes and chromosomes using chicken DT40 cells. In 1999, he joined the National Institute of Genetics as an Assistant Professor, where he began investigating the molecular architecture of centromeres/kinetochores using a combination of disciplines such as genetics, biochemistry, cell biology, genome sciences, and structural biology. He has been promoted through the ranks to the current position of Professor, as of 2008, in the National Institute of Genetics. In 2015, Tats moved to the Graduate School of Frontier Bioscience at Osaka University.

What turned you on to biology in the first place? When I was a student in junior high school, I was interested in humanities rather than natural sciences. I loved to study the history of Japan and imagined how leaders made their decisions in each period. I especially liked leaders in the transition from the Edo Era to the Meiji Era, which is called 'The Meiji Restoration' (Meiji Ishin). In that period, there were many changes in Japan. Because I was also interested in studying political science, I planned to take a course in the department of political science in a university, when I was a high school student. However, I found that it was hard to visualize achievements that could be made in the field of political science. I completely changed my mind at that point, and wanted to work with visual products. Since Japan is a small country, there are few food resources. However, the development of science technologies is active in Japan. Therefore, I decided to tackle the challenge of generating useful food resources using biotechnological approaches.

First, I took a course on 'Food Science and Technology' at Hokkaido University. Although I tried to work on genetic engineering of marine bacteria in an undergraduate course, I became acutely aware that I had to gain additional knowledge in molecular biology to successfully work in the field of genetic engineering. At that time, I realized that without a deep understanding of basic science, we can never carry out research in the field of applied science. I decided to enroll in a graduate course at the National Institute of Genetics (NIG) to study basic molecular biology and genetics.

What did you learn at NIG? I really enjoyed my graduate course at NIG. I learned a lot of basic molecular biology and genetics, as well as experimental skills in related areas at NIG. I was so eager to conduct experiments that sometimes I would even forget to eat my meals. I really concentrated on performing these experiments. Although I enrolled in the graduate course to devote my work to applied science, I found I liked molecular biology much more. Later in my graduate course, I started to think about postdoctoral study abroad in the field of molecular biology.

Why did you choose Oxford for your postdoctoral training? I studied human genome organization as a main project in my graduate course at NIG. We focused on chromosome banding patterns in humans and tried to identify band boundaries at the molecular level to understand the biological significance of chromosome banding. Because a complete genome was not available at that time, I did chromosome walking from a high-GC rich region to a low-GC rich region and finally cloned the sharp boundaries of chromosome bands. These corresponded to the boundaries in timing of DNA replication. Although it was a rather fun project, the biological significance of chromosome banding was not so clear. I decided I would like to study more on defined functional chromosomal domains, such as centromeres and telomeres. One day, I read a paper by William Brown and his colleagues, which described trials to create a human artificial chromosome (HAC) through a telomere-directed breakage assay. I was very impressed by their unusual approach, and was also aware that William and some of his colleagues worked in the lab of Ed Southern, the famous inventor of the 'Southern blot' technique. I expected to gain new insights by working with William and Ed and decided to join Oxford as a postdoctoral fellow.

How was life in Oxford? Japan is a more isolated country than Europe, and it was the first time I was living in a foreign country. At first, it was not so easy for me and my family to adjust to life in England. Language was a definite problem, making it difficult to communicate with colleagues, and I was mostly silent when I started going to Oxford. However, I worked very hard in the lab and, within a year, I had established a conditional knockout chicken DT40 cell line for CENP-C. At that time, chicken DT40 was not a major experimental system, and William had just introduced these cells to his team as a host to create HACs. Since DT40 shows frequent homologous recombination, he imagined that DT40 cells would be a good system for the telomere-directed breakage assay. I myself tried to use this cell line to analyze gene function through a gene-knockout approach. Since I was interested in centromeres, I tried to clone a chicken homologue of CENP-C, which had just been identified as a centromere protein in humans, and to establish a conditional knockout for CENP-C. Although this was not a super achievement, I devised a method to make conditional knockout cells by myself and then generated the cell lines. At this point, colleagues recognized me as a talented postdoc and I gained the confidence to do research at Oxford. I made good friends there, who were very kind and helpful for my studies. After this, I enjoyed life for the next 3 years in Oxford. Of course, I learned serious scientific attitudes from William and Ed.

Then, did you go back to Japan? Yes. One night, I got a telephone call from my Japanese mentor, Prof. Toshimichi Ikemura, asking me whether I would be interested in an Assistant Professor position at NIG. As you may know, the system in Japanese universities and institutes is quite different from that in the USA. There were no independent positions for young scientists at that time. Currently, the Japanese system is changing. Now, young scientists can look for independent positions in each university, even though there still are not many positions. Even if this offer was an Assistant Professor position, I would be working in a team under Prof. Ikemura. If I wanted an independent position, I would have to apply for such positions in the USA or Europe. I thought deeply about my future, and I decided to go back to Japan. I was sure that I would find merits in Japanese research and could conduct proper good science in this country. Fortunately, Prof. Ikemura allowed me to take up my own project. In this project, I tried to identify new kinetochore components from chicken DT40 cells under the guidance of his team. I greatly appreciate his generous attitude. After three years, I was provided with my own lab in NIG and continued to study centromeres/kinetochores independently. I consider myself very lucky.

What is the most exciting result in your scientific experience? I love lab work, and so I am always excited to see new results. The most exciting result may have been my first look at a new kinetochore protein. When we tried to identify new kinetochore components using a proteomics approach in early 2000, we found sequences of new candidates for kinetochore components. We cloned full-length cDNA of each candidate based on these sequences and made GFP-fused cDNAs. We checked the expression and localization of each GFP-fused clone under the

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microscope. After looking at many images of negative clones, I was very excited to observe nice punctate signals in the nucleus, suggesting a positive clone. I remember that I cried in the dark room. By continuing this experiment, we found many constitutive centromere proteins, which are now called 'CCAN' proteins. This series of experiments determined the direction of my research career.

Do you continue to study centromeres/kinetochores? Yes. In the two decades since this experiment, we have continued to look for components of kinetochores, and I believe that most components have been identified. The next question is how these proteins are organized to generate functional kinetochores. Since there are over 100 different kinetochore proteins, it is not easy to address this question. At the same time, several researchers, including our lab, began to reconstitute a part of the kinetochore structure. Although this is a very important experiment, we had to first understand the organization of the native kinetochore structure. I believe that understanding kinetochore structure and function is the best way to understand how chromosomes segregate equally into daughter cells. There are many important general questions that we should address in biology. You might feel that studies on chromosome segregation or kinetochore structure are a bit restricted or limited, but that is not true. If we continue our studies in this field, we may find answers to unexpected new questions, because chromosomes are the fundamental structures in every cell. For this reason, I would like to encourage young scientists to join this field. I am sure that we will still get to reveal several unexpected phenomena in this area of science.

Is Japan a good place to conduct research? This is a difficult question. Of course, we have a strong tradition of chromosome research, and there are many researchers in Japan working on chromosomes. Needless to say, though, the centers of scientific research are based in the USA and Europe. For example, major journals are published in the USA or Europe. Therefore, we must communicate with scientists in the USA or Europe. Today, as communication tools are well developed, it is possible to talk easily with scientists abroad using Skype or email. However, it is still much better to talk with colleagues in person, and these opportunities are limited. In addition, many talented students and postdocs want to join labs in the USA or Europe. Considering this, I cannot say that Japan is the best country in which to conduct science. However, there are clear merits in Japanese science. For example, Japanese people are good at teamwork, and individual abilities of Japanese students are not less than those of students in the USA. Although we are generally not very skilled at writing manuscripts or responding effectively to hard reviews, we can learn many things from the scientific communities in the USA and Europe through this process. I have actually received many useful suggestions from reviewers, and this process trained me quite well, and could also be done in Japan. If I organize a good team in Japan, utilizing these merits in Japanese science, I believe that we can produce better scientific achievements from Japan. I recently moved to a new place (Osaka University). Here, I will try to organize the best team possible.

Since I have been supported by the Japanese scientific community, I feel obligated to train young Japanese scientists to be active in scientific research as part of the world community. In recent years, the Japanese government has been promoting globalization. True globalization is possible if each scientist is active and recognized in his or her research field.

Recently, the Japanese government has also demonstrated a trend towards supporting medical science rather than basic science in the field of biology. However, as I learned early on, excellent research in the field of applied science (including medical science) requires a deep understanding of basic science. Since Japan has a strong background in chromosome research, I hope that the Japanese government will continue to support our basic research, which will contribute to the overall development of medical research and help to train excellent 'global' young scientists.

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Quick guide

Predatory grasshopper mice

Ashlee H. Rowe* and Matthew P. Rowe

What are grasshopper mice? Grasshopper mice are big-eared, big-eyed, nocturnal rodents closely related to deer mice. They are relatively small (they are mice, after all!), only 120–190 mm long, about the length of a pencil, including their stubby, fat tail; adults typically weigh between 20 and 50 grams, the weight of about eight pennies for a small individual, 20 pennies for a bruiser. There are just three species, all in the genus *Onychomys*, the southern, northern, and Mearns' (or Chihuahuan) grasshopper mouse, respectively. Their geographical distribution is restricted to the short-grass prairies, shrub deserts, and desert grasslands of the western United States and northern Mexico, with the range of one species, the northern grasshopper mouse, extending into the northern Great Plains of south-central Canada.

Why are they called 'grasshopper mice'? The mice earned this epithet because they aren't the timid, hide-in-the-corners, seed-eating, cheese-stealing pantry pests many people think of when they hear the label 'mouse'. They are top-level carnivores, ferocious killers little different, besides their diminutive size, from a cheetah, coyote, or stoat. Early explorers of the American west ascribed two equally common names to the mice once their predatory lifestyles had been recognized — grasshopper mouse in some regions, and scorpion mouse in areas with an abundance of these arachnids. While grasshopper mice eat some plant material, and have been recorded killing and eating lizards, birds, and even other mice, a significant majority of their diet is arthropods including, obviously, grasshoppers and scorpions (Figure 1).

Are they the only carnivorous rodents? Actually, no. Indeed, the common perception of rodents as primarily herbivorous is erroneous. Many rodents are omnivorous and some, like ground squirrels, frequently include